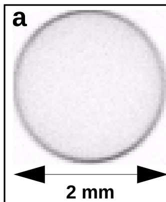
June 2001 Highlights of the Pulsed Power Inertial Confinement Fusion Program



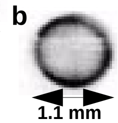


Fig. 1a) Preshot 4.75-keV radiograph of capsule with 60-μm-thick wall. b) ZBL radiograph of same capsule, 14 ns after peak radiation temperature on Shot 767.

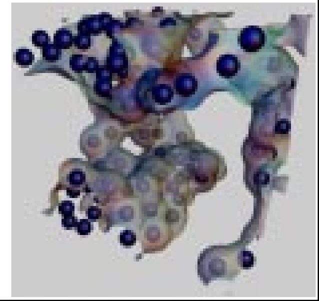


Fig. 2. Representation of mixed liquid-vapor and insulator phase from QMD calculations.

This month we accomplished two major stockpile stewardship milestones on Z: 1) We recorded the first backlit x-ray images of an imploding capsule (e.g., Fig. 1) with the 2-kJ Z-Beamlet laser (ZBL) on Shots 765 and 767 (June 25 and 29). 2) We got preliminary isentropic compression experiment (ICE) data to 2 Mbars for Al. The backlit images mark completion of a level-1 FY01 milestone of the ICF Campaign--i.e., completion of the ZBL construction project. Obtaining the Al data was a major FY01 objective of the Dynamic Material Properties Campaign that required extensive modification of Z hardware on the bottom level.

The total Z shots in June were 12. Seven were ICE shots. The ICE shots demonstrate the extent to which the technique is being applied to measure material properties. We got optical and mechanical data on PMMA (a plastic) to 300 kbars, data on the optical response of window materials (to 500 kbars for LiF and to 1 Mbar for sapphire), data on Al to 2 Mbars, and D_2 data from 350-700 kbars. On the remaining shots, we continued to assess Ti K-shell output using CH_2 foam for DTRA (2 shots) and and we prepared for and got ICF capsule images with the ZBL diagnostic using point projection (3 shots), as part of a study on Z to assess the applicability of the z-pinch-driven hohlraum for high yield.

Point projection forces the image plane detector to view through a large aperture, making the images sensitive to bremsstrahlung and debris. The data indicate progress in overcoming these sensitivities using a magnetically-driven shutter (see Aug 00 Highlights). The second x-ray radiograph on Z with ZBL (Fig. 1b) was taken June 29. In this experiment, we imaged a 2-mm-dia, moderate-convergence-ratio capsule. The final focusing optics assembly (FOA) used was designed, built, and installed by Sandia. We are now beginning the next phase in implementing ZBL on Z: to achieve precise timing between the Z and ZBL pulses, complete a permanent FOA, and obtain multiple images on a single experiment. When fully commissioned, ZBL will have a <50-μm-dia spot size and a four-component picket-fence pulse to get high-resolution, point-projection multiple-frame x-ray images.

Many high-energy-density physics experiments with wire-array z pinches, imploding liners, and exploding wires evolve through complex conductivity and equation of state (EOS) regimes, beginning at solid density and transitioning through liquid and vapor states to the plasma state. In particular, for z-pinch implosions and magnetically-launched flyer plates, an accurate knowledge of the phase space near the metal-insulator and the solid-liquid-vapor transitions is important to predict the behavior as intense currents are introduced at early time. Careful comparison with experiments for both aluminum flyer plate and exploding wire simulations indicated that the electrical conductivities in the liquid Al regime were probably not sufficiently accurate to obtain a high fidelity correspondence. Quantum molecular dynamics (QMD) simulations with the Vienna Ab initio Simulation Package (VASP), coupled with an ab initio calculation of the electrical conductivities using the Kubo-Greenwood formula, have permitted a refinement of the Lee-More-Desjarlais (LMD) conductivities (see July 99 highlights) in this regime. The revised conductivities are now in use in the ALEGRA and MACH2 codes, and the resulting agreement between the simulations and experiments is very good. Figure 2 shows an example configuration from a QMD simulation; the phase separation characteristic of densities and temperatures within the vapor dome is evident.

Contact: Keith Matzen, Inertial Confinement Fusion Program, Dept. 1670, 505-845-7756, fax: 505-845-7464, email: mkmatze@sandia.gov
Highlights are prepared by Mary Ann Sweeney, Dept. 1670, 505-845-7307, fax: 505-845-7464, email: masween@sandia.gov.
Archived copies of the *Highlights* beginning July 1993 are available at http://www.sandia.gov/pulspowr/hedicf/highlights.